# 5. Actor model using the Akka framework

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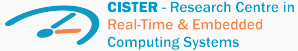
https://fm-dcc.github.io/pc2324





# Overview

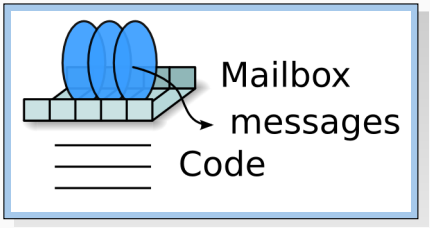
# We are here

**Blocks of sequential code running concurrently and sharing memory:**

- What is Scala?
- Concurrency in Java and its memory model
- Basic concurrency blocks and libraries
- *Futures and Promises*
- *Data-Parallel Collections*
- *Reactive Programming (Concurrently)*
- *Software Transactional Memory*
- Actor model

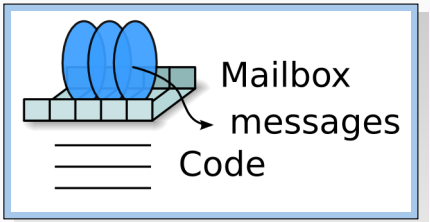
# What is the actor model

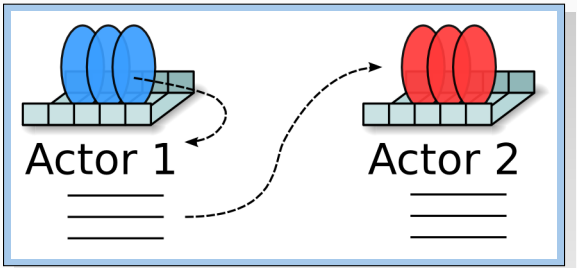
- Asynchronous message exchange between actors
- Introduced in Erlang (we use Akka's actor library)



# What is the actor model

- Asynchronous message exchange between actors
- Introduced in Erlang (we use Akka's actor library)
- Active, autonomous, no shared memory, no synchronisation



# What we will see

We will use the Akka framework for actors for:

- Declaring actor classes and creating actor instances
- Modelling actor state and complex actor behaviours
- Manipulating the actor hierarchy and the actor lifecycle
- The different message-passing patterns used in actor communication
- Error recovery using the built-in actor supervision mechanism
- Using remote actors to build concurrent and distributed programs

Documentation: `https://doc.akka.io/docs/akka`

# Creating actors

# Core concepts

**Actor system**

Hierarchical group of actors with shared configurations, supporting actor creation and logging.

**Actor class**

Template that describes the states and behaviour of an actor, used to create instances.

**Actor instance**

Entity that exists at runtime, with a state and capable of sending and receiving messages.

**Mailbox**

Memory block that is used to buffer messages for a given actor instance.

**Actor reference**

Object that allows an object to send messages to a specific actor instance.

**Dispatcher**

Component that decides when actors are allowed to process messages. In Akka every dispatcher is also an execution context.

# My first actor (class) in Akka

```
import akka.actor._
import akka.event.Logging

class HelloActor(val hello: String)
    extends Actor {
  val log = Logging(context.system, this)
  def receive = {
    case ‘hello‘ =>
      log.info(
        s"Received␣a␣’$hello’...␣$hello!")
    case msg     =>
      log.info(
        s"Unexpected␣message␣’$msg’")
      context.stop(self)
  }
}
```

- Each `HelloActor` receives messages
- ... if it receives its `hello`, it logs and continues
- ... if it receives something else, it stops
- `context` – provides core functions, such as `stop`
- `self` – is the instance's actor reference

# Configuring an actor in Akka

```
object HelloActor { // companion
  // two factory methods below
  def props(hello: String) =
    Props(new HelloActor(hello))
  def propsAlt(hello: String) =
    Props(classOf[HelloActor], hello)
  //def propsAlt2 = Props[HelloActor]
}
```

## Actor configuration

- actor class
- constructor arguments
- mailbox
- dispatcher

## Props

- can receive a block of code, used each time a new actor instance is created;
- can receive a `Class` object and its arguments
- can be sent over the network (should be self-contained)
- avoid creating `Props` in the actor class, and use factory methods instead

# My first actor system with an instance

```
// in build.sbt:
libraryDependencies ++= Seq( ...
  ,"com.typesafe.akka" %% "akka-actor" % "2.8.5"
  ,"com.typesafe.akka" %% "akka-remote" % "2.8.5"
)
```

```
lazy val ourSystem = akka.actor.ActorSystem("OurExampleSystem")
```

```
object ActorsCreate extends App {
  val hiActor: ActorRef =
    ourSystem.actorOf(HelloActor.props("ola"), name = "greeter")
  hiActor ! "ola"
  Thread.sleep(1000)
  hiActor ! "hi"
  Thread.sleep(1000)
  ourSystem.terminate()
}
```

# Unhandled messages?

```
class DeafActor extends Actor {
  val log = Logging(context.system, this)
  def receive = PartialFunction.empty
  override def unhandled(msg: Any) = msg match {
    case msg: String => log.info(s"I␣do␣not␣hear␣'$msg'")
    case msg         => super.unhandled(msg)
  }
}
```

```
object ActorsUnhandled extends App {
  val deafActor: ActorRef =
    ourSystem.actorOf(Props[DeafActor], name = "deafy")
  deafActor ! "ola"
  Thread.sleep(1000)
  deafActor ! 1234
  Thread.sleep(1000)
  ourSystem.terminate()
}
```

# Modelling actor behaviour

# My 2nd example in Akka: a (stateful) countdown

```
class CountdownActor extends Actor{
  var n = 10
            // never do this
  def receive = if (n > 0) {
    case "count" =>
      log(s"n␣=␣$n")
      n -= 1
  } else PartialFunction.empty
}
```

# My 2nd example in Akka: a (stateful) countdown

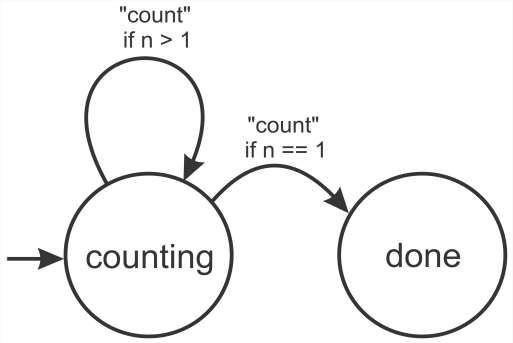
Not allowed in Akka:

```
class CountdownActor extends Actor{
  var n = 10
            // never do this
  def receive = if (n > 0) {
    case "count" =>
      log(s"n␣=␣$n")
      n -= 1
  } else PartialFunction.empty
}
```

Correct in Akka, using become:

```
class CountdownActor extends Actor {
  val log = Logging(context.system,
      this)
  var n = 10
  def counting: Actor.Receive = {
    case "count" =>
      n -= 1
      log.info(s"n␣=␣$n")
      if (n == 0) context.become(done)
  }
  def done = PartialFunction.empty
  def receive = counting
}
```

# Actor as a transition system



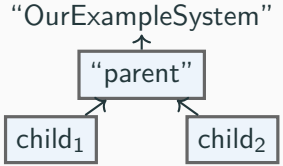

[in *"Learning Concurrent Programming in Scala"*, pg. 278]

# Running the countdown

```
object ActorsCountdown extends App {
  val countdown = ourSystem.actorOf(Props[CountdownActor])
  for (i <- 0 until 20) countdown ! "count"
  Thread.sleep(1000)
  ourSystem.terminate()
}
```

# Actor hierarchy and lifecycle

# New example with a parent



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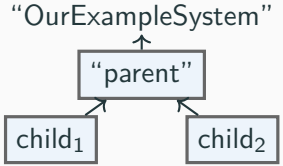
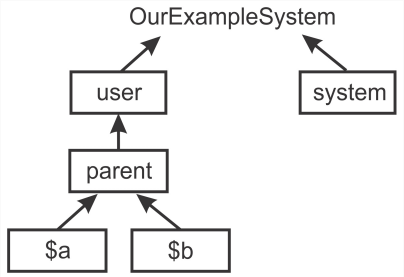



```
class ChildActor extends Actor {
  val log =
      Logging(context.system, this)
  def receive = {
    case "sayhi" =>
      val parent = context.parent
      log.info(s"my parent $parent
          made me say hi!")
  }
  override def postStop() {
    log.info("child stopped!")
  }
}
```

```
class ParentActor extends Actor {
  val log = Logging(context.system,
      this)
  def receive = {
    case "create" =>
      context.actorOf(Props[ChildActor])
      log.info(s"created a kid;
          children =
          ${context.children}")
    case "sayhi" =>
      log.info("Kids, say hi!")
      for (c <- context.children) c !
          "sayhi"
    case "stop" =>
      log.info("parent stopping")
      context.stop(self)
  }
}
```

# A more complete view of the hierarchy

```
object ActorsHierarchy extends App {
  val parent =
      ourSystem.actorOf(Props[ParentActor],
      "parent")
  parent ! "create"
  parent ! "create"
  Thread.sleep(1000)
  parent ! "sayhi"
  Thread.sleep(1000)
  parent ! "stop"
  Thread.sleep(1000)
  ourSystem.terminate()
}
```




in *"Learning Concurrent Programming in Scala"*, pg. 284

- ActorSystem
- sys.terminate
- sys/ctxt.actorOf
- ctxt.stop
- ctxt.become
- ctxt.children
- ctxt.parent

# A more complete view of the hierarchy

- parent actor stops $\Rightarrow$ its children stop
- user and system:
  are guardian actors – at the top of the hierarchy, to log, restart actors, etc.
- hierarchy visible when printing an actor ref, e.g., for the first child;
  `akka://OurExampleSystem/user/parent/$a`

# A more complete view of the hierarchy

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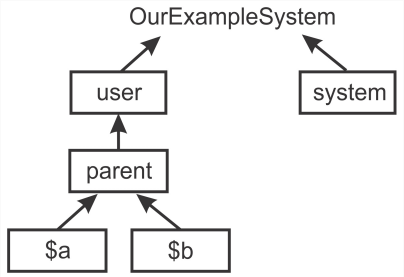
  are guardian actors – at the top of the hierarchy, to log, restart actors, etc.
- hierarchy visible when printing an actor ref, e.g., for the first child;
  `akka://OurExampleSystem/user/parent/$a`
- Next: `ctxt.actorSelection(path)`

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- ActorSystem
- sys.terminate
- sys/ctxt.actorOf
- ctxt.stop
- ctxt.become
- ctxt.children
- ctxt.parent

# Discovering actors in the hierarchy

```
class CheckActor extends Actor {
  val log = Logging(context.system, this)
  def receive = {
    case path: String =>
      log.info(s"checking␣path␣$path")
      context.actorSelection(path) ! Identify(path)
    case ActorIdentity(path, Some(ref)) =>
      log.info(s"found␣actor␣$ref␣at␣$path")
    case ActorIdentity(path, None) =>
      log.info(s"could␣not␣find␣an␣actor␣at␣$path")
  }
}
```

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  val log = Logging(context.system, this)
  def receive = {
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      context.actorSelection(path) ! Identify(path)
    case ActorIdentity(path, Some(ref)) =>
      log.info(s"found actor $ref at $path")
    case ActorIdentity(path, None) =>
      log.info(s"could not find an actor at $path")
  }
}
```

```
val checker = ourSystem.actorOf(Props[CheckActor], "checker")

checker ! "../*"       // finds the checker and its siblings
checker ! "../../*"    // finds user and system guardians
checker ! "/system/*" // finds internal actors
checker ! "/user/checker2" // logs that no actors were found
```

# Once an actor throws an exception...

When an actor throws an exception, a new "replacement" actor is created, with the same:

- arguments
- mailbox
- ActorRef

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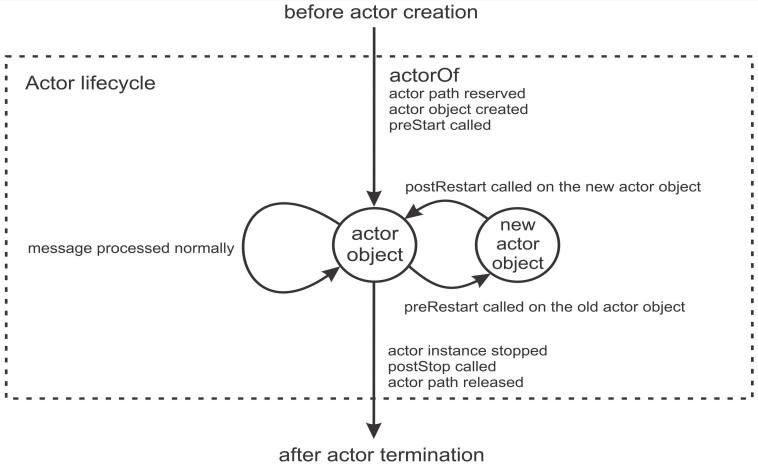
- arguments
- mailbox
- ActorRef
  - hence never leak the actual this reference!

# Actor lifecycle

- Created – `actorOf`
- Before starting to process messages – `preStart()`
- After an exception – `preRestart(t: Throwable, msg: Option[Any])`
  - before creating a new actor
  - when all children are stopped
- After recreating a restarted actor – `postRestart(t: Throwable)`
  - the new actor is then assigned the previous mailbox
- After an actor terminates – `postStop()`
  - called by the default implementation of `preRestart`

# Actor lifecycle in a diagram




[in *"Learning Concurrent Programming in Scala"*, pg. 289]

# Synchrony vs. Asynchrony

# Sending x and y from A to B

**Synchronous (as in CCS)**

$A = x!\,.\,y!$

$B = x?\,.\,y?$

$A \mid B \backslash \{x, y\}$

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$x!$ happens before $y!$

$x?$ happens before $y?$

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**Asynchronous (as in Akka)**

$x!$ happens before $y!$

$x?$ happens before $y?$

$x!$ happens before $x?$

$y!$ happens before $y?$

$y!$ ?? $x?$

# Sending x and y from A to B

## Synchronous (as in CCS)

$A = x! \,.\, y!$

$B = x? \,.\, y?$

$A \mid B \backslash \{x, y\}$

$\Rightarrow \quad \tau_x . \tau_y$

Different formalisations for global beh.:

- Message sequence charts
- Event structures
- Automata over interactions
- Choreographies:
  $A \to B : x \;\; ; \;\; A \to B : y$

## Asynchronous (as in Akka)

$x!$ happens before $y!$

$x?$ happens before $y?$

$x!$ happens before $x?$

$y!$ happens before $y?$

$y!$ ?? $x?$

No duplication

No messages lost

No messages reordered

No blocking send

Synchrony modelled with Asynchrony?

and vice-versa?

# Diamond problem: sending by two routes

$A \rightarrow B : x;$
$A \rightarrow C : y;$
$C \rightarrow B : z$

$B$ must be ready to receive '$x?$' and '$z?$' by any order

# Error recovery with actors

# Stopping an actor

**Main ways to stop an actor:**

- `context.stop(act)` – stops `act` and its children, once it finishes processing their current message
- `Kill` message – restarts the target actor once it is received
- `PoisonPill` message – stops the target actor after once it is processed

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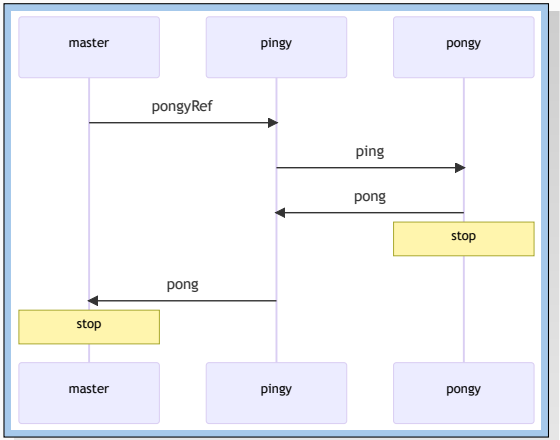
**Stopping in more complex scenarios:**

- Using Akka's DeathWatch (next slide)

# Pingy-Pongy example



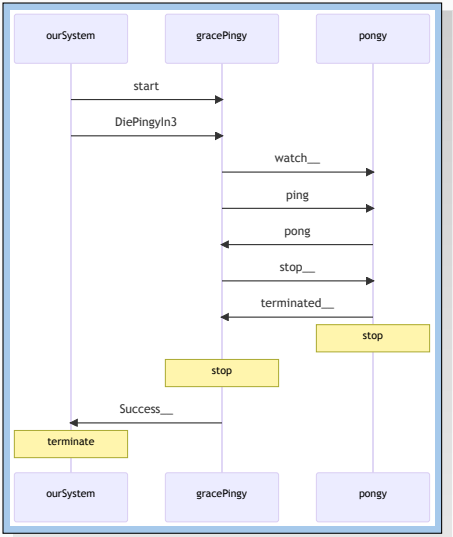

- Example used in the book to illustrate the ask-reply pattern
- (in pingy: `val reply = pongy ? "ping"`)
- We will adapt it for a graceful shutdown

# Graceful Pingy-Pongy

```
class GracefulPingy extends Actor {
  val log = Logging(context.system, this)
  val pongy =
    context.actorOf(Props[Pongy], "pongy")
  context.watch(pongy)
  def receive = {
    case "start" => pongy ! "ping"
    case "pong"  => log.info("Got␣a␣pong")
    case "Die,␣Pingy!" =>
      context.stop(pongy)
    case Terminated(`pongy`) =>
      context.stop(self)
} }
```

```
class Pongy extends Actor {
  val log =
    Logging(context.system,this)
  def receive = {
    case "ping" =>
      log.info("Got␣a␣ping␣--␣
          ponging␣back!")
      sender ! "pong"
  }
  override def postStop() =
      log.info("pongy␣going␣
      down")
}
```

# Running the gracefull app




## Mechanism 1 (pingy ↔ pongy)

- `context.watch(pongy)` – the `DeathWatch`
- wait for `Terminated` message

## Mechanism 2 (ourSystem ↔ pingy)

- ask to `"Die"`
- check if it terminated – using Futures

# Running the gracefull app (code)

```
import akka.pattern.gracefulStop

object CommunicatingGracefulStop extends App {
  val gracePingy = ourSystem.actorOf(Props[GracefulPingy], "gracePingy")
  gracePingy ! "start"

  val stopped = gracefulStop(gracePingy, 3.seconds, "Die␣Pingy!")
  stopped onComplete { // stopped is a Future (not covered)
    case Success(x) =>
      log("graceful␣shutdown␣successful")
      ourSystem.terminate()
    case Failure(t) =>
      log("grace␣not␣stopped!")
      ourSystem.terminate()
} }
```

# Handling children's exceptions (Actor supervision)

```
class Naughty extends Actor {
  val log = Logging(context.system,this)
  def receive = {
    case s: String => log.info(s)
    case msg => throw new
        RuntimeException
  }
  override def postRestart(t:Throwable)=
    log.info("naughty␣restarted")
}
```

```
import SupervisorStrategy._
class Supervisor extends Actor {
  context.actorOf(Props[Naughty],
      "naughty")
  def receive = PartialFunction.empty
  override val supervisorStrategy =
    OneForOneStrategy() {
      case ake: ActorKilledException
          => Restart
      case _ => Escalate
} }
```

```
ourSystem.actorOf(Props[Supervisor], "super")
val children = ourSystem.actorSelection("/user/super/*")
children ! "hello" // succeeds
children ! Kill    // stops naughty, but super restarts it
children ! "sorry␣about␣that" // succeeds
children ! "kaboom".toList    // naughty and super throw exception
```

# Remote actors over TCP

# Compilation with remote actors

`build.sbt` needs to import akka-remote:

```
libraryDependencies ++= Seq(
    ...
  ,"com.typesafe.akka" %% "akka-actor" % "2.8.5" // or older
  ,"com.typesafe.akka" %% "akka-remote" % "2.8.5"
)
```

Network configured with Netty library

```
import com.typesafe.config._
def remotingConfig(port: Int) = ConfigFactory.parseString(s"""
  akka {
    actor.provider = "akka.remote.RemoteActorRefProvider"
    remote {
      enabled-transports = ["akka.remote.netty.tcp"]
      netty.tcp {
        hostname = "127.0.0.1"
        port = $port }
    }
  }""")
def remotingSystem(name: String, port: Int): ActorSystem =
     ActorSystem(name, remotingConfig(port))
```

# Remote Pingy-Pongy – running two Apps!

```
object RemotingPongySystem extends App {
  val system =
        remotingSystem("PongyDimension",
        24321)
  val pongy = system.actorOf(Props[Pongy],
        "pongy")
  Thread.sleep(15000)
  system.terminate()
}
```

```
object RemotingPingySystem extends App {
  val system =
        remotingSystem("PingyDimension",
        24567)
  val runner = system.actorOf(Props[Runner],
        "runner")
  runner ! "start"
  Thread.sleep(5000)
  system.terminate()
}
```

```
class Runner extends Actor {
  val log = Logging(context.system, this)
  val pingy = context.actorOf(Props[Pingy], "pingy")
  def receive = {
    case "start" =>
      val pongySys =
            "akka.tcp://PongyDimension@127.0.0.1:24321"
      val pongyPath = "/user/pongy"
      val url = pongySys + pongyPath
      val selection = context.actorSelection(url)
      selection ! Identify(0)
    case ActorIdentity(0, Some(ref)) =>
      pingy ! ref
    case ActorIdentity(0, None) =>
      log.info("Something's␣wrong␣-␣ain't␣no␣pongy␣
            anywhere!")
      context.stop(self)
    case "pong" =>
      log.info("got␣a␣pong␣from␣another␣dimension.")
      context.stop(self)
  }
}
```

# Running the multi-dimensional Pingy-Pongy

- Start the `RemotingPongySystem`
- Start the `RemotingPingySystem` within 15 sec.
- Use different SBT instances
- Runner in `PingyDimension` should get a “pong” soon

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- Use different SBT instances
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**Deployment logic vs. Application logic**

- Deployment log.: setting up network communication
- Application log.: interactions between agents
- These should be kept in separate
- In our example, `Runner` handles deployment logic

# Wrapping up remote actors

## Steps for handling remote actors

- Declaring each actor system with appropriate remoting configuration
- Starting each actor system in separate processes or on separate machines
- Obtain actor references by using actor path selection
- Transparently send messages by using these actor references

# Wrapping up Actors

- Declare actor classes and create actor instances
- Model actor state and complex actor behaviours
- Manipulate the actor hierarchy and the actor lifecycle
- Use some message-passing patterns used in actor communication
- Use error recovery with the built-in actor supervision mechanism
- Use remote actors to build concurrent and distributed programs

Documentation: `https://doc.akka.io/docs/akka`